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ONTARIO WATER RESOURCES COMMISSION

REPORT

on

WATER QUALITY

in

KAHSHE LAKE

1971

RECREATIONAL LAKES PROGRAM

THE

ONTARIO WATER RESOURCES COMMISSION

REPORT

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SUMMARY

A study to evaluate the status of water quality in Kahshe Lake was carried out during the summer of 1971.

Kahshe Lake lies in the Precambrian Shield. The area is characterized by undulating land, good local drainage and shallow overburden covering Precambrian bedrock. The shoreline is dominated by rock and boulder till with an occasional area of thin overburden. Both the nature of the soil and topography surrounding the lake can be considered unsuitable for cottage development utilizing standard subsurface septic tank systems.

Thermal stratification was observed in the lake, coupled with an oxygen depletion and a carbon dioxide increase in the hypolimnion. A carbon dioxide buildup was observed between the surveys.

The chemical water quality was characteristic of soft-water Precambrian lakes. The use of detergents containing phosphorus is unnecessary in such soft water and should be avoided by area residents.

Nitrogen and phosphorus concentrations were generally low, however, the concentrations were consistently high near the inlet of the Kahshe River.

Chlorophyll _a_ concentrations were low and reflect a low to moderate productive capacity or mesotrophic status.

Kahshe Lake had good bacteriological water quality, well within the OWRC criteria for recreational use, during the three surveys. However, slightly increased bacterial concentrations were consistently observed near the inlet of the Kahshe River and at the Kahshe River outlet.

In order to maintain the existing water quality every effort should be made to ensure that no direct flow or leachate from domestic waste disposal systems or other potential sources of pollution gain access to the lake.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Water Resources Commission, the Ontario Department of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Department of the Environment in December 1971, would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, raw wastes or septic tank effluents must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface water is considered safe for human consumption without prior treatment including disinfection. The algae and weed growths impair aesthetic values and recreational use of a lake but seldom pose a health hazard. There are nutrient sources other than sewage wastes which do not create serious bacterial hazards but do support nuisance plant growths such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In order to carry out its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Kahshe Lake in the summer of 1971. Three surveys were conducted; a spring survey from May 27 to 31, a mid-summer survey from August 24 to 26 and a fall survey from October 11 to 15 inclusive. These studies included the assessment of bacteriological, physical, chemical and biological conditions of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

Sampling surveys were conducted on an intensive basis (sampling each day for a minimum of five days) which is mandatory for a reliable assessment of bacteriological conditions.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution control program in Ontario.

AREA DESCRIPTION

Geography and Topography

Kahshe Lake is located in the Town of Gravenhurst, District Municipality of Muskoka and is approximately 11 kilometers (7 miles) southeast of the urban area of Gravenhurst.

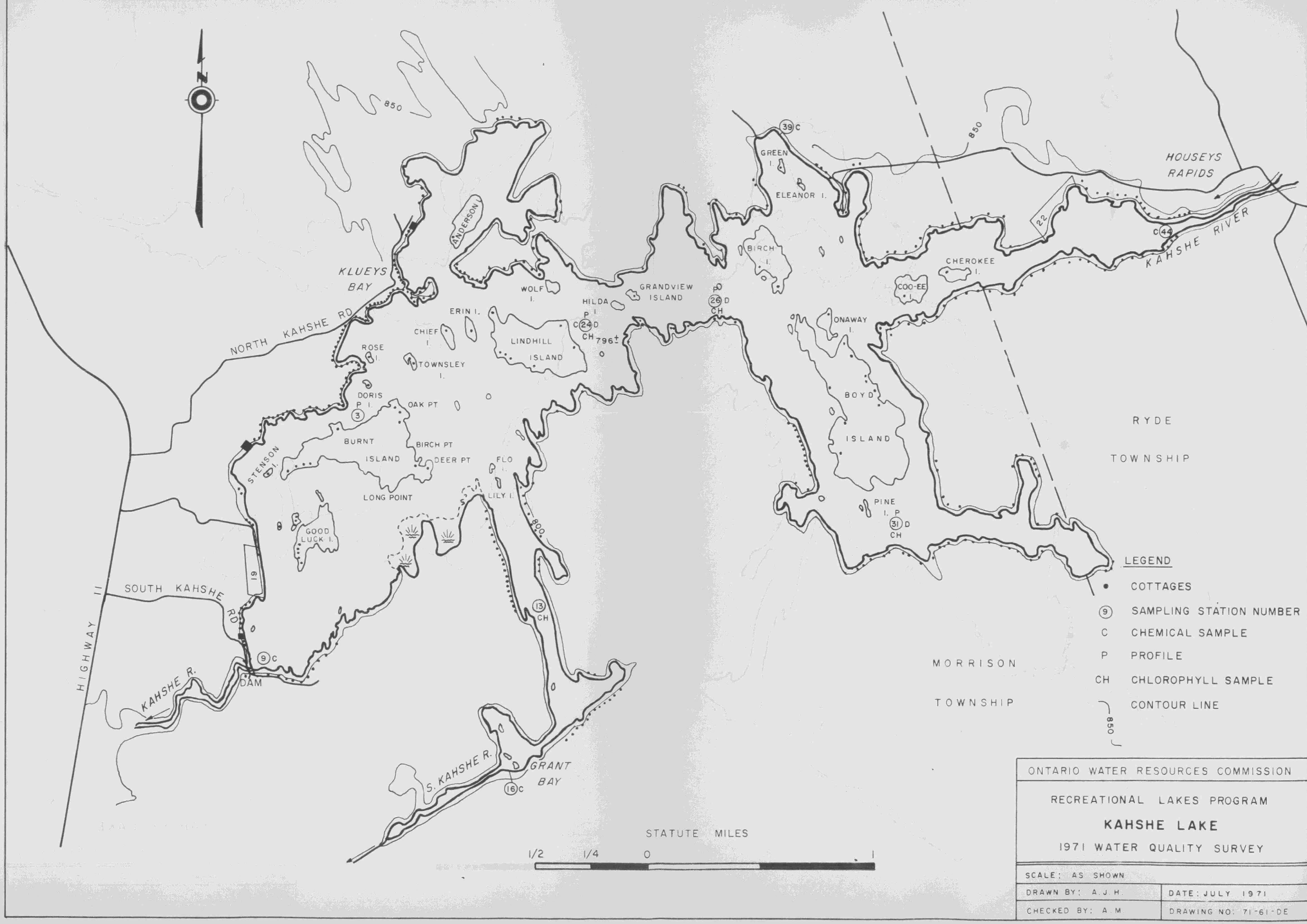
Kahshe Lake lies in the Canadian Shield. It is a stellate-shaped lake dotted with many islands and rock outcroppings (Figure 1). It has 52 kilometers (32 miles) of irregular shoreline with an additional 23 kilometers (14 miles) of island shoreline. It has a surface area of 8 square kilometers (3 square miles) excluding 1 square kilometer (0.4 square miles) of islands. The lake has a maximum depth of 20 meters (66 feet), however two-thirds of its surface area is less than 6 meters (20 feet) deep. Its total volume is approximately 68 cubic hectometers (55,000 acre feet).

The immediate watershed of the lake, which includes the area draining into the Kahshe and Gartersnake rivers and the small lakes through which they flow, consists of 220 square kilometers (86 square miles) of hilly to undulating land. The land is mostly granite rock with little or no overburden and pockets of Wendigo soil. This soil is a loamy sand with a Podzol profile and offers good drainage. It is strongly acidic and consists almost entirely of a medium-sized sand. The shoreline is dominated by rock and boulder till, with an occasional area of thin overburden. The surrounding area is moderately to heavily forested with a mixture of deciduous and coniferous trees. Both the nature of the soil and topography surrounding the lake can be considered as unsuitable for cottage development utilizing standard subsurface septic tank systems.

Climatic Range

The area has a mean daily temperature of $-9.4^{\circ}C$ ($15^{\circ}F$) in January and a mean temperature of $19^{\circ}C$ ($66^{\circ}F$) in July. The mean annual precipitation is 1 meter (40 inches) including 2.5 meters

FIGURE 1


KLUEYS BAY
NORTH KAHSHE RD
ANDERSON I.
WOLF I.
ERIN I.
CHIEF I.
ROSE I.
TOWNSLEY I.
LINDHILL ISLAND
HILDA I.
GRANDVIEW ISLAND
796±
DORIS I.
OAK PT
BURNT ISLAND
BIRCH PT
DEER PT
STENSON I.
LONG POINT
FLO
LILY I.
GOOD LUCK I.
SOUTH KAHSHE RD
HIGHWAY 11
KAHSHE R.
DAM
S. KAHSHE R.
GRANT BAY
GREEN I.
ELEANOR I.
BIRCH I.
HOUSEYS RAPIDS
KAHSHE RIVER
CHEROKEE I.
COO-EE I.
ONAWAY I.
BOYD ISLAND
PINE I.
RYDE TOWNSHIP
MORRISON TOWNSHIP
850
800
STATUTE MILES
1/2 1/4 0 1
LEGEND
COTTAGES
SAMPLING STATION NUMBER
C CHEMICAL SAMPLE
P PROFILE
CH CHLOROPHYLL SAMPLE
CONTOUR LINE
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(96 inches) of snow. According to meteorological records, the area enjoys about 200 days yearly with no measurable precipitation. The summer climate is conducive to most recreational activities and the winter with its abundance of snow provides for participation in most winter sports.

Water Movement

Kahshe Lake is part of the Georgian Bay Terminal Drainage Basin. Bass Lake, which is fed by the Kahshe and Gartersnake rivers, flows into Kahshe Lake via the Kahshe River which, is one of the lake's two major inlets. The other inlet is a small creek flowing into the lake at Station 39, from Three Mile Lake. The two outlets are in the southwest part of the lake with the major outlet being Kahshe River. Its outflow is controlled by a stop-log dam which is owned by the Department of Lands and Forests and operated by the Town of Gravenhurst. The other outlet is the South Kahshe River which flows intermittently from the southwest tip of Grant Bay to join the main branch of the Kahshe River about 3 kilometers (2 miles) downstream. The Kahshe River then flows into Sparrow Lake which flows via the Severn River into Georgian Bay.

Shoreline Development

There are approximately 430 cottages on Kahshe Lake. The lake is well developed around Klueys Bay, the southwest bay near the Kahshe River outlet, and along both shores of the northeast bay near the Kahshe River inlet.

Water Usage

The majority of the cottage owners use the lake water as their source of domestic water supply. The lake supports recreational water sports such as fishing, boating, water skiing and swimming. According to information available from the Department of Lands and Forests, the lake supports a reasonably good fishery of smallmouth bass, herring, yellow perch, pike, muskellunge and various forage species.

There are no direct discharges of wastes into Kahshe Lake from communal or municipal sewage treatment facilities. There does not appear to be any contamination from the operation of the existing municipal solid waste disposal sites.

Physical, Chemical and Biological Field Methods

Physical, chemical and biological water quality surveys were conducted on Kahshe Lake from May 27 to 31, August 20 to 24 and October 11 to 15 inclusive. Three near-shore Stations (9, 16 and 44) and four mid-lake stations (3, 24, 26 and 31) were selected for physical, chemical and biological sampling (Figure 1). Near-shore stations were close to major inlets and outlets.

Dissolved oxygen and temperature profiles were determined daily in the field using a combination dissolved oxygen-telethermometer unit. Total alkalinity and free carbon dioxide were measured daily titrimetrically and pH was measured with a portable pH meter. Daily chlorophyll samples were collected in a 32-ounce bottle, at each station, utilizing a composite sampler lowered through the euphotic zone (2X Secchi disc) and immediately preserved with 10 - 15 drops of 2% $MgCO_3$.

Once per survey a 32-ounce sample for hardness, alkalinity, chloride, total phosphorus, total Kjeldahl nitrogen, iron and conductivity was collected at the mid-lake Stations 24, 26 and 31, as well as at the major inlets and outlets. The mid-lake stations were sampled using a composite sampler through the euphotic zone. At inlets and outlets, samples were collected from 1 meter of depth using a Kemmerer sampler. Extra chemical samples were also collected at Stations 26 and 31 on August 25 and 26.

Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 liter samples were filtered through a 1.2 μ membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths 600 to 750 mu using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll a were calculated using the equation given by Richards and Thompson (1952).

Bacteriological Field and Laboratory Methods

Five day intensive bacteriological surveys were completed on Kahshe Lake during May, August and October. Forty-four stations were sampled each day at a depth of 1 meter below the surface using sterile, autoclavable polycarbonate 250 ml bottles. Additonal samples were collected at Stations 24D, 26D and 31D (Figure 5) one meter above the bottom using a modified "piggy-back" sampler and sterile 237 ml evacuated rubber air syringes. All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analysed for total coliforms, fecal coliforms and fecal streptococcus using the membrane filtration technique (MF) (Standard Methods 13th Edition) except that m-Endo Agar Les (Difco) was used for fecal coliform determinations . The total coliforms (TC) fecal coliforms (FC) and fecal streptococcus (FS) were used as "indicators" of fecal pollution. These "indicators" are the normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing micro-organisms may also be present.

The coliform group is defined, according to Standard Methods 13th Edition, as "all of the aerobic and faculative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C" and, or "all organisms which produce a colony with a golden green metallic

sheen within 24 hours of incubation" using the MF technique. This definition includes, in addition to the intestinal forms of the Escherichia coli group, closely related bacteria of the genera Citrobacter and Enterobacter. The Enterobacter - Citrobacter groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the Escherichia group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for Escherichia coli, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin.

Bacteriological Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial numbers and this type of data is the geometric mean. The vast quantities of bacteriological data generated from these samples necessitated the development of additional statistical methods to summarize the mean results into a more concise presentation. The statistical methods used are based on the analysis of variance. The stations on a lake can be grouped by this

method into areas or groups of stations with the same statistical bacterial level, without the bias normally associated with manual interpretation.

The analysis of variance is particularly effective where bacterial concentrations vary slightly throughout the lake. Areas or stations with slight differences in bacterial concentrations can be isolated. Areas or stations with statistically higher bacterial numbers reliably indicate an input.

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm) was calculated on each station and for each parameter. The validity of the analyses of variance program (ANOVA-CRE: Burger, 1972), was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed. Both these assumptions were checked on Kahshe Lake with the result that stations 3, 26 and 46 had excessively high variances in their TC counts during the October survey and had to be treated separately. The analysis of variance (F-test; Sokal, 1969) was calculated in all the stations. If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program unitl each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data from the three surveys.

DISCUSSION OF RESULTS

Temperature and Dissolved Osygen

In May there was a temperature difference of $8^{\circ}C$ between the surface ($15^{\circ}C$) and bottom ($7^{\circ}C$) waters (Figure 2a). Dissolved oxygen saturations were lower in the deeper strata (78% saturation) than in the surface waters (110% saturation).

During August, a well-defined thermocline was evident between 6 and 9 meters (Figure 2b). A significant dissolved oxygen decrease was evident through the metalimnion with low oxygen values in the hypolimnion. Hypolimnetic oxygen deficits result from bacterial oxidation of organic matter, biological respiration and chemical oxidation of organic material. The reduced oxygen in the bottom water indicates that there was not a great deal of circulation between the bottom and surface.

During the October survey, thermal stratification was absent at Station 24 (Figure 3a). The uniform temperature and dissolved oxygen saturations indicate that autumnal circulation had occurred. In contrast, at Station 31, (Figure 3b) fall turnover was not complete. A severe oxygen decline occurred through the metalimnion (63% to 8% saturation), probably as a result of decomposition of organic matter.

pH, Total Alkalinity and Free Carbon Dioxide

The pH values in Kahshe Lake were slightly acidic, being consistent with soft-water Precambrian Lakes. In general, the surface pH values were higher than those of the deeper strata. For example, at Station 31 on August 21, values at 1 and 16m were 6.3 and 5.3 respectively.

Surface alkalinity values were low and ranged from 3.8 to 10.2 mg/1, 3.2 to 6.1 mg/1 and 4.8 to 13.5 mg/1 for the May, August and October surveys respectively. Alkalinity values were generally higher in the bottom than in the surface waters. Specifically, on May 29 at Station 24, values were 6.5 and 7.2 mg/1 at 1m and immediately above the

Figure 2a

Figure 2b

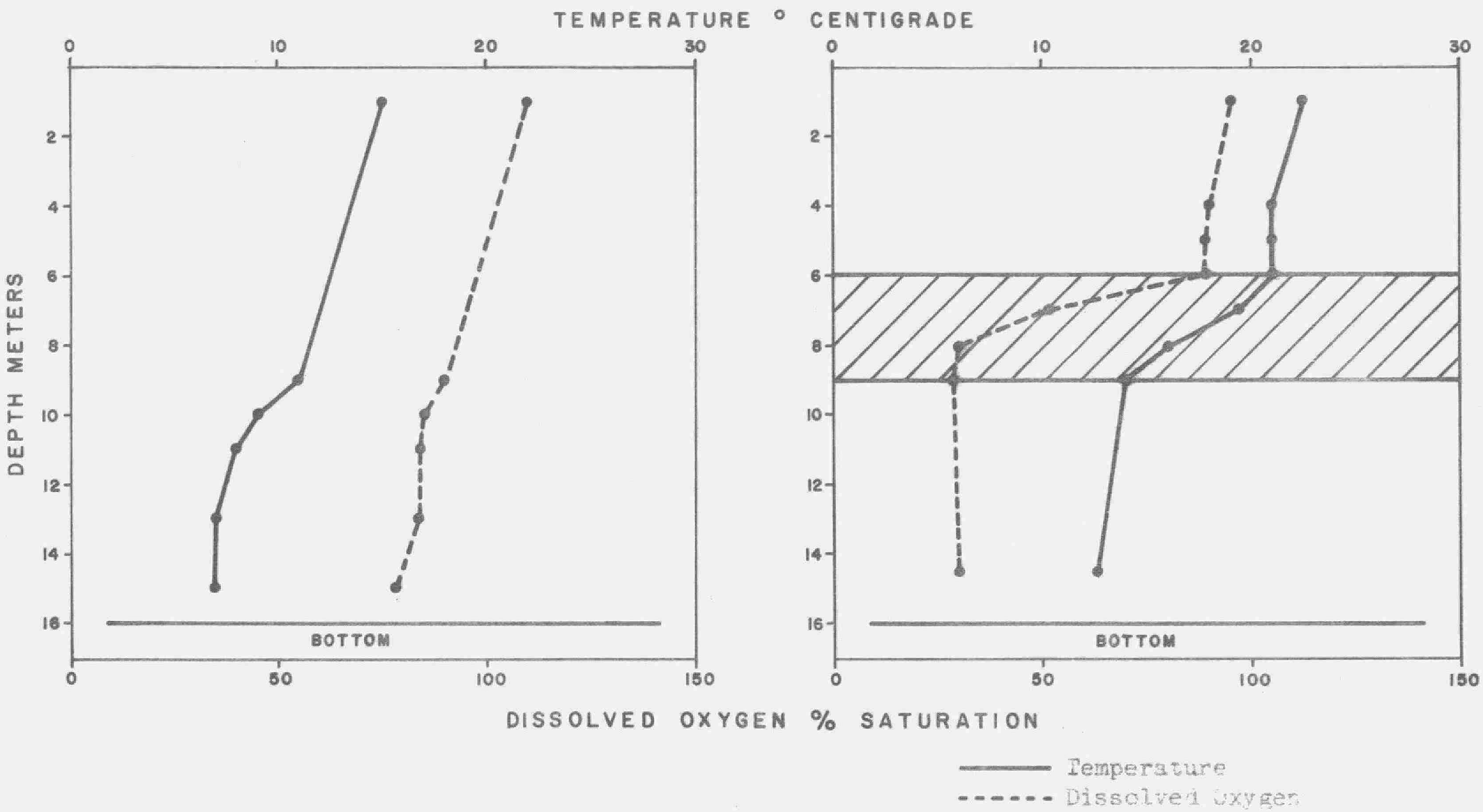

Figure 2: Temperature and dissolved oxygen profiles in Kahshe Lake, Station 24 on (a) May 31, 1971 and (b) August 23, 1971. The shaded area approximates the position of the thermocline.

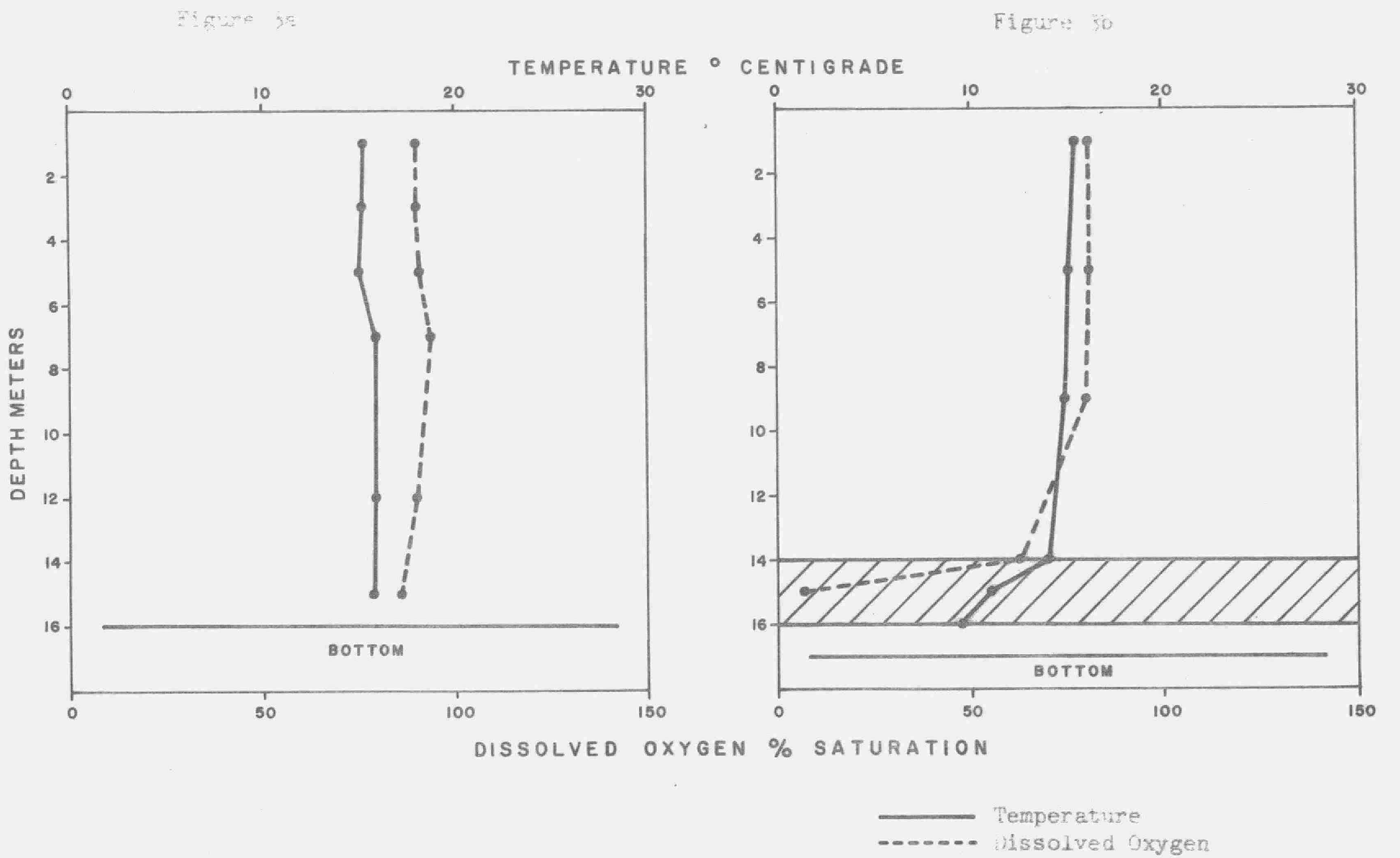

Figure 3: Temperature and dissolved oxygen profiles in Kahshe Lake (a) Station 24 on October 11, 1971 and (b) Station 31 on October 14, 1971. The shaded area approximates the area of the thermocline.

sediment respectively. A build up of carbon dioxide was evident in the bottom waters of Station 31 where the concentration was 6.0 mg/l on May 31, 14.3 mg/l on August 23 and 21.7 mg/l on October 14.

Reduced pH values in the hypolimnion are due to the accumulation of carbon dioxide derived from organic decomposition while the increased alkalinity is related to the release of bicarbonate from sediments by bacterial and chemical action in conjunction with calcium, magnesium, iron, manganese and ammonia.

Hardness, Chloride, Conductivity and Iron

The hardness chloride conductivity and iron data (Table 1) were normal for soft-water Precambrian lakes and were consistent with each other confirming that no unusual mineral characteristics were present. Detergents containing phosphorus are unnecessary in such soft water and their use should be avoided by area residents.

Kjeldahl Nitrogen and Total Phosphorus

Surface concentrations of Kjeldahl nitrogen and total phosphorus (Table 1) at the mid-lake stations were generally low and would not be expected to cause any algal problems. There were high concentrations of both nutrients at the surface at Station 24 on May 27 and in the hypolimnion at Station 31 in October. Total phosphorus concentrations tended to be higher in the surface water near the end of the August survey but decreased during the extra two days of sampling (August 25 and 26).

Concentrations of both nitrogen and phosphorus were consistently high near the inlet of the Kahshe River.

Chlorophyll a

The chlorophyll a concentrations and Secchi disc values from Stations 13, 24, 26 and 31, are presented in Table 1. Chlorophyll a levels were low to moderate during the three sampling periods, ranging

from 1.8 to 3.1 µg/l, 2.9 to 6.4 µg/l and 1.3 to 3.2 µg/l for the May, August and October surveys respectively. These values are indicative of low algal populations.

Water clarity, which is one of the more important parameters used in defining water quality, may be measured using a Secchi disc. Figure 4 presents a chlorophyll a - Secchi disc relationship for a number of surface waters and reflects the "trophic status" of Kahshe Lake in relation to numerous other well known recreational lakes in the Province (see Brown 1972 for derivation of chlorophyll a Secchi disc relationship). With respect to Figure 4, Kahshe Lake is positioned in close proximity to values observed for Lake Ontario and Eastern Basin of Lake Erie and is well removed from Gravenhurst Bay and Riley Lake (District of Muskoka), two extremely enriched bodies of water. The lake is well displaced from oligotrophic Lake Joseph and may therefore be classified as mesotrophic.

Bacteriology

Kahshe Lake during the three survey periods was well within the criteria for total body contact recreational use of 1000 TC/100 ml, 100 FC/100 ml and 20 FS/100 ml, based on a geometric mean of not less than 10 samples in one month (OWRC, 1970).

In the May survey, the majority of stations were included in Group A (Figure 5) with overall geometric mean (GM) bacterial levels of 38 TC/100 ml, 1 FC/100 ml and 1 FS/100 ml. The TC levels of the three depth stations (24D, 26D, 31D) were uniformly lower than Group A. Station 22, in a wide bay with very little cottage development, and Station 38, a mid-lake station, both had lower TC concentrations of 15/100 ml and 16/100 ml respectively.

Two small areas, Group B at the major outflow and Group C at the major inflow displayed slightly higher FC levels than Group A (Table 3). Group B with a geometric mean of 5 FC/100 ml indicated a slight bacterial input probably from the lodge and marina near Station 8. Group C, with a GM level of 4 FC/100 ml indicated a bacterial input from the Kahshe River and Bass Lake (Figure 5).

FIGURE 4

CHLOROPHYLL a - SECCHI DISC RELATIONSHIP

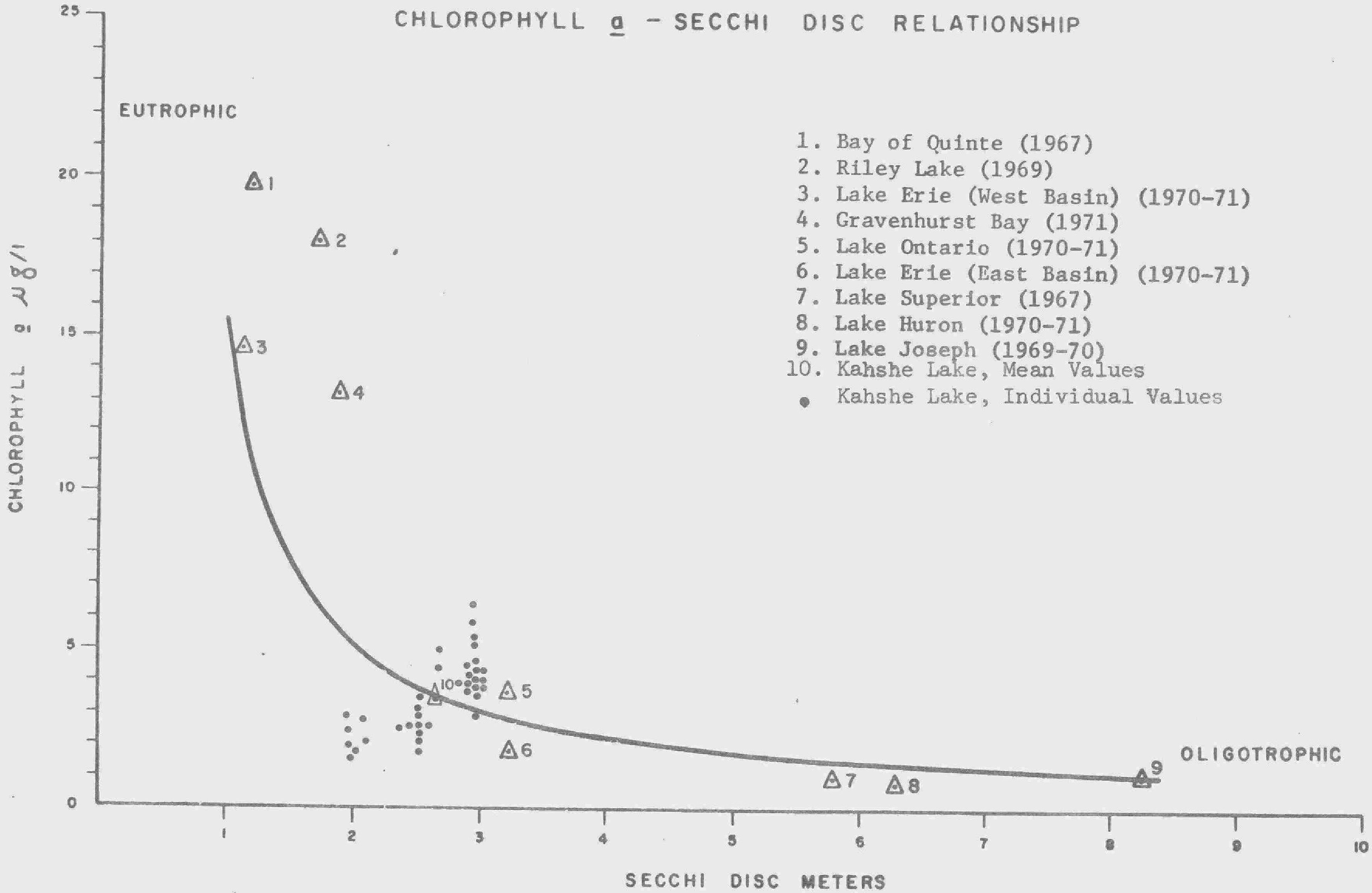

Figure 4: The relationship between chlorophyll a and Secchi disc as determined from the recreational lakes surveyed in 1971 as well as the individual chlorophyll a - Secchi disc values for Kahshe Lake. The Great Lake values were added for comparative purposes.

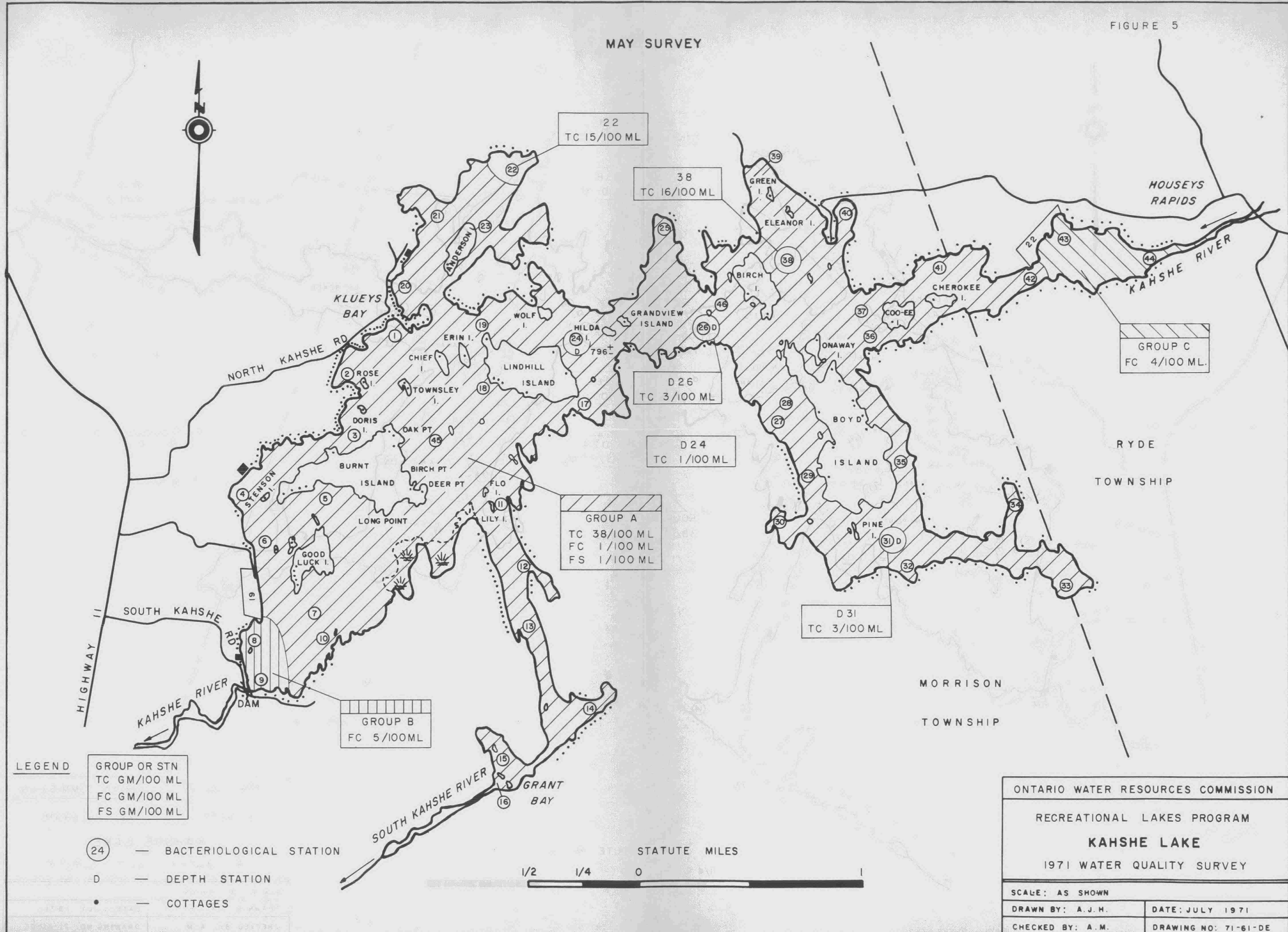
FIGURE 5
MAY SURVEY
22
TC 15/100 ML
38
TC 16/100 ML
D 26
TC 3/100 ML
D 24
TC 1/100 ML
D 31
TC 3/100 ML
GROUP A
TC 38/100 ML
FC 1/100 ML
FS 1/100 ML
GROUP B
FC 5/100 ML
GROUP C
FC 4/100 ML.
HOUSEYS RAPIDS
KAHSHE RIVER
KLUEYS BAY
NORTH KAHSHE RD
SOUTH KAHSHE RD
HIGHWAY 11
KAHSHE RIVER
DAM
SOUTH KAHSHE RIVER
GRANT BAY
ANDERSON
WOLF I.
HILDA I.
D 796
GRANDVIEW ISLAND
GREEN I.
ELEANOR I.
BIRCH I.
CHEROKEE I.
COO-EE I.
ONAWAY I.
BOYD ISLAND
PINE I.
ERIN I.
CHIEF I.
TOWNSLEY I.
LINDHILL ISLAND
ROSE I.
DORIS I.
OAK PT
BIRCH PT
DEER PT
BURNT ISLAND
STENSON I.
LONG POINT
GOOD LUCK I.
FLO I.
LILY I.
RYDE TOWNSHIP
MORRISON TOWNSHIP
LEGEND
GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
24 — BACTERIOLOGICAL STATION
D — DEPTH STATION
• — COTTAGES
STATUTE MILES
1/2 1/4 0 1
ONTARIO WATER RESOURCES COMMISSION
RECREATIONAL LAKES PROGRAM
KAHSHE LAKE
1971 WATER QUALITY SURVEY
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DRAWING NO: 71-61-DE

In August, the majority of the lake (Group A) had mean bacterial concentrations of 11 TC/100 ml, 2 FC/100 ml and 2 FS/100 ml (Figure 6). Groups B, C and G at the southwest end of Kahshe Lake were characterized by a significantly higher FC level of 18/100 ml. Groups B and G had higher FS levels of 6/100 ml and Group B, encompassing the major outflow, had a higher TC concentration of 148/100 ml. These higher bacterial levels were attributed to heavy recreational use associated with the cottage development and the lodge and marina in that area.

A statistically higher FC level of 5/100 ml was recorded at Group D at the northeast section of the lake. However, Station 44, at the inflow from the Kahshe River showed the lowest FC level of this group implying an additional input from the cottaged shoreline bordering the remaining three stations of Group D. Higher FC concentrations were also observed at Stations 30 and 40 and Groups E and F (Figure 6) and a slightly higher FS concentration was observed at Station 2. The Muskoka Airport Climatological Station recorded .16 inches of rainfall on August 22. These slightly increased bacterial levels may have resulted from rainfall induced runoff.

In October, the FC and FS densities were uniformly low throughout Kahshe Lake at 2/100 ml and 1/100 ml respectively, with the exception of several isolated stations that had statistically higher mean levels. These exceptions were: Station 34 with 6 FC/100 ml and 4 FS/100 ml, Station 43 with 4 FS/100 ml, Group G with 4 FS/100 ml and Station 2, within Group G with 5 FC/100 ml (Figure 7). Stations 26 and 46 (Group F) and Station 3 showed very high variance in TC counts and had to be placed in a separate grouping (Bartlett's Test of Homogeneity). Group F, situated at a narrows, divided Kahshe Lake into two major non-significantly different (Student's t; $t = 0.6055$; degrees of freedom, $df = 167$) groups: Group A with 326 TC/100 ml and Group B with 547 TC/100 ml. Although removed, Group F and Station 3 had means similar to the main body of the lake (Figure 7) implying similar bacteriological conditions prevailed over most of the lake. Group C, at the inflow from Bass Lake via the Kahshe River exhibited a lower TC concentration of 127/100 ml. Groups D and E, at

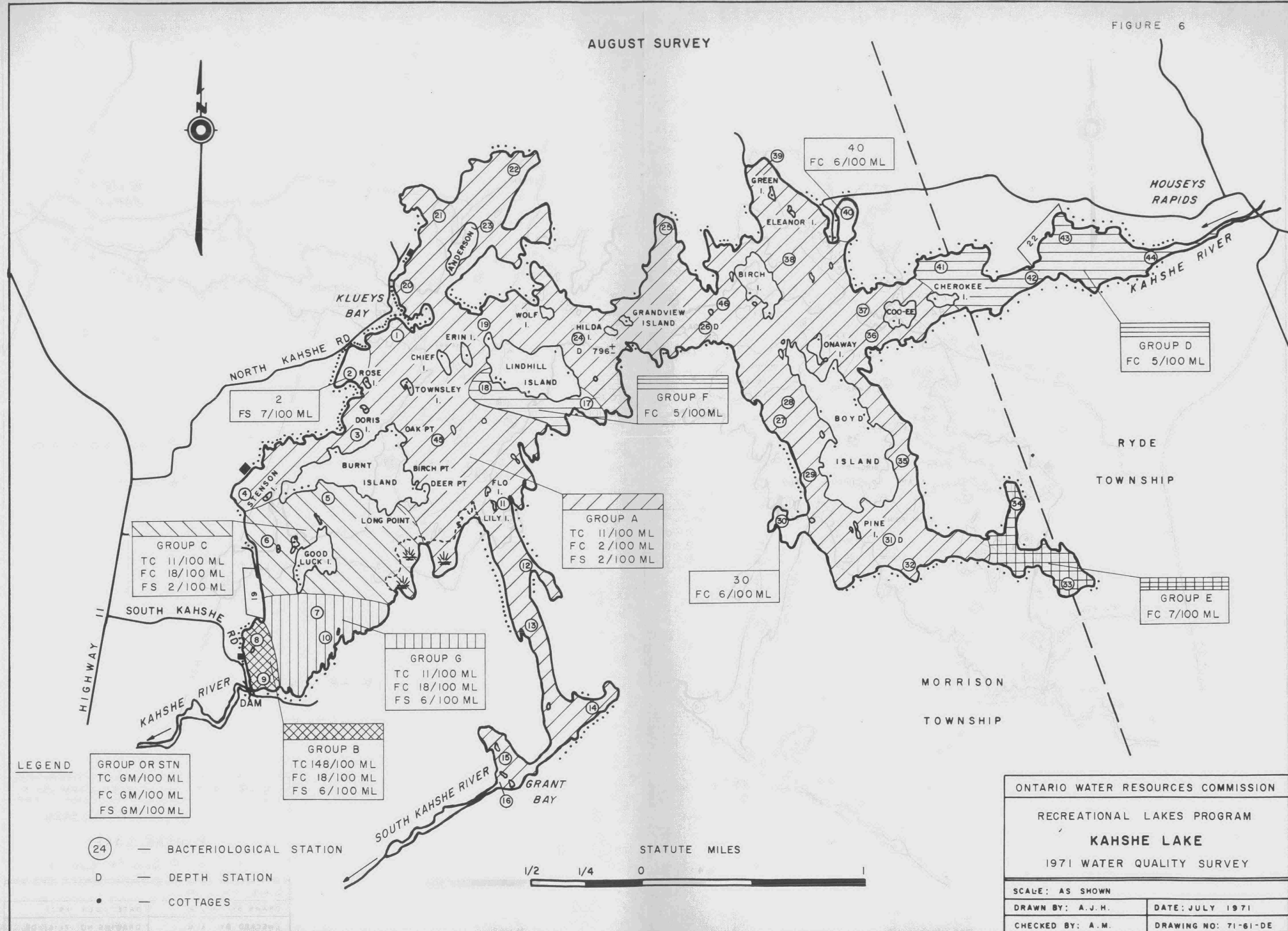
FIGURE 6
AUGUST SURVEY
N
KLUEYS BAY
NORTH KAHSHE RD
2
FS 7/100 ML
40
FC 6/100 ML
HOUSEYS RAPIDS
KAHSHE RIVER
GROUP D
FC 5/100 ML
GROUP F
FC 5/100ML
GROUP A
TC 11/100 ML
FC 2/100 ML
FS 2/100 ML
GROUP C
TC 11/100 ML
FC 18/100 ML
FS 2/100 ML
30
FC 6/100ML
GROUP E
FC 7/100 ML
GROUP G
TC 11/100 ML
FC 18/100 ML
FS 6/100 ML
GROUP B
TC 148/100 ML
FC 18/100 ML
FS 6/100 ML
ANDERSON
WOLF I.
HILDA I.
D 796±
GRANDVIEW ISLAND
GREEN I.
ELEANOR I.
BIRCH I.
CHEROKEE I.
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MORRISON TOWNSHIP
SOUTH KAHSHE RD
HIGHWAY 11
11
KAHSHE RIVER
DAM
SOUTH KAHSHE RIVER
GRANT BAY
LEGEND
GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
24 — BACTERIOLOGICAL STATION
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1/2 1/4 0 1
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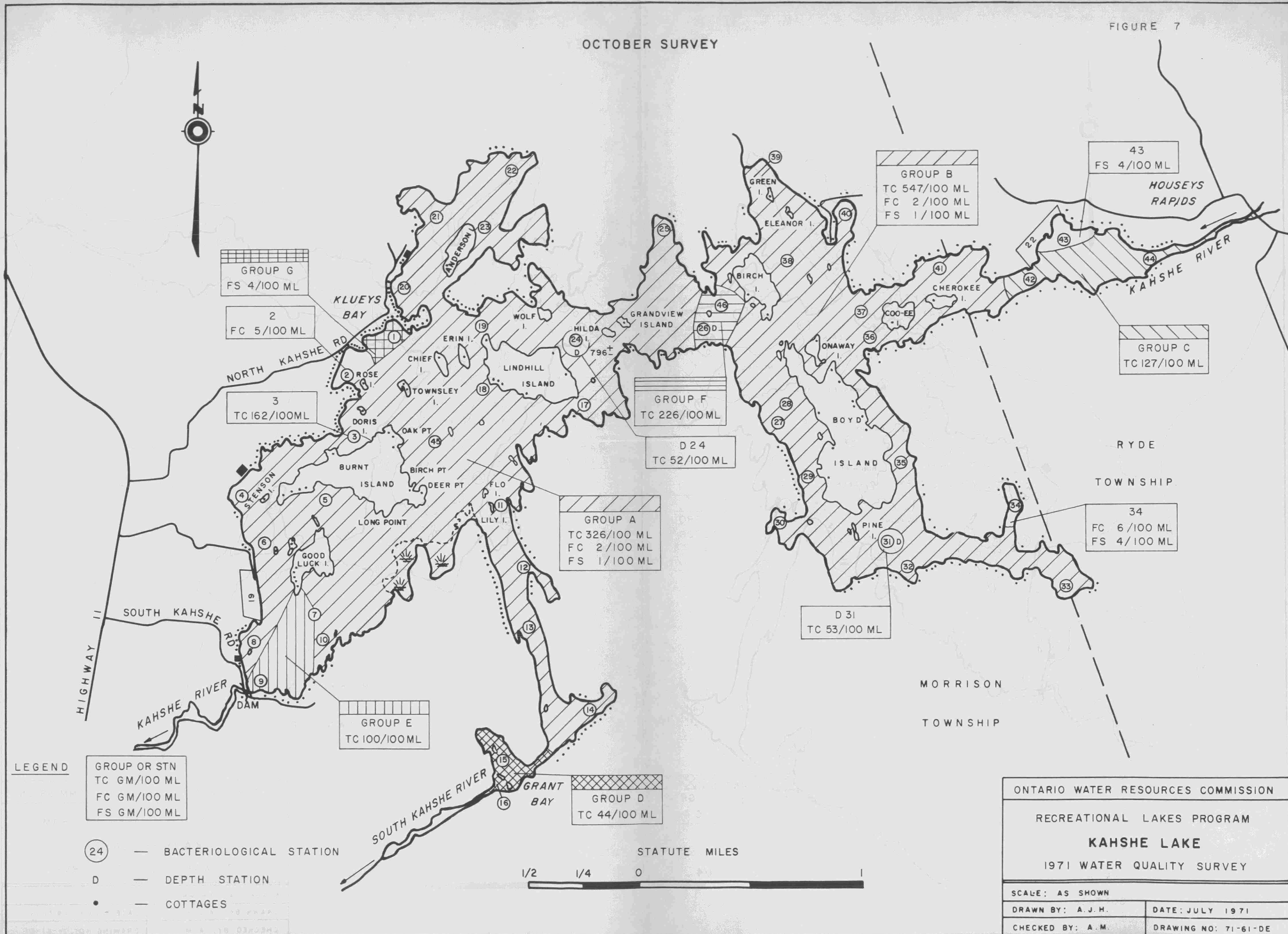


FIGURE 7
OCTOBER SURVEY
N
GROUP G
FS 4/100 ML
2
FC 5/100 ML
3
TC 162/100ML
KLUEYS BAY
NORTH KAHSHE RD
SOUTH KAHSHE RD
HIGHWAY 11
KAHSHE RIVER
DAM
GROUP E
TC 100/100ML
LEGEND
GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
24 — BACTERIOLOGICAL STATION
D — DEPTH STATION
• — COTTAGES
SOUTH KAHSHE RIVER
GRANT BAY
GROUP D
TC 44/100 ML
GROUP A
TC 326/100 ML
FC 2/100 ML
FS 1/100 ML
GROUP F
TC 226/100 ML
D 24
TC 52/100 ML
GROUP B
TC 547/100 ML
FC 2/100 ML
FS 1/100 ML
43
FS 4/100 ML
HOUSEYS RAPIDS
KAHSHE RIVER
GROUP C
TC 127/100 ML
34
FC 6/100 ML
FS 4/100 ML
D 31
TC 53/100 ML
RYDE TOWNSHIP
MORRISON TOWNSHIP
ANDERSON I.
WOLF I.
HILDA I.
796±
GRANDVIEW ISLAND
ERIN I.
CHIEF I.
ROSE I.
TOWNSLEY I.
LINDHILL ISLAND
DORIS I.
OAK PT
BURNT ISLAND
BIRCH PT
DEER PT
STENSON I.
LONG POINT
FLO I.
LILY I.
GOOD LUCK I.
GREEN I.
ELEANOR I.
BIRCH I.
CHEROKEE I.
COO-EE I.
ONAWAY I.
BOYD ISLAND
PINE I.
STATUTE MILES
1/2 1/4 0 1
ONTARIO WATER RESOURCES COMMISSION
RECREATIONAL LAKES PROGRAM
KAHSHE LAKE
1971 WATER QUALITY SURVEY
SCALE: AS SHOWN
DRAWN BY: A.J.H.
DATE: JULY 1971
CHECKED BY: A.M.
DRAWING NO: 71-61-DE

the two main outflows with 44 TC/100 ml and 100 TC/100 ml respectively were both significantly lower than the main body of the lake (Table 3). The depth stations (24D and 31D) also had significantly lower TC concentrations of 52/100 ml and 53/100 ml respectively.

Generally, the FC and FS concentrations remained very low throughout the three surveys. In May, the TC concentrations on the lwke were low. In August, the TC levels were even lower, however these low levels may be attributed to the masking effect resulting from a ten to twenty fold increase in background bacteria from May to August. The TC levels in October were much higher than in either previous survey probably because of the presence of normal soil organisms in the lake which, although not indicative of fecal pollution, gave a positive TC reaction. Although the lake was well within the OWRC criteria for recreational use during the three surveys completed, all surface water should receive treatment, including disinfection, before it can be considered potable.

TABLE 1

Iron, Hardness (Hard.), Total Phosphorus (P), Kjeldahl Nitrogen (N), Chloride (Cl) and Conductivity (Cond.), for Kahshe Lake 1971. The results are expressed as mg/l except conductivity which is μmho/cm^3.

Station	Depth	Date	Iron	Hard.	P	N	Cl	Cond.
9	1m	29/5	0.25	11	0.008	0.28	1	32
16	1m	29/5	0.25	11	0.012	0.56	1	32
24	4m	27/5	0.25	12	0.052	0.74	1	34
	14m	27/5	0.40	11	0.016	0.50	1	34
26	4m	27/5	0.25	11	0.020	0.36	1	34
	20m	27/5	0.45	12	0.044	0.56	1	33
31	1m	28/5	0.40	11	0.016	0.24	1	32
31	1m	29/5	0.25	11	0.008	0.26	1	32
44	1m	29/5	0.35	11	0.052	0.54	1	35
9	1m	24/8	0.25	12	0.024	0.24	2	33
16	1m	24/8	0.20	12	0.022	0.34	2	32
24	6m comp	24/8	0.20	12	0.020	0.42	2	32
26	6m comp	24/8	0.20	12	0.032	0.36	2	32
26	6m comp	25/8	0.20	11	0.016	0.42	2	33
26	6m comp	26/8	0.20	11	0.015	0.38	2	32
31	5.4m comp	24/8	0.20	12	0.028	0.44	2	33
31	6m comp	25/8	0.15	11	0.014	0.35	2	33
31	5.6m comp	26/8	0.15	11	0.014	0.36	2	33
44	1m	24/8	0.40	12	0.036	0.56	2	32
9	1m	15/10	-	11	0.024	0.43	2	-
16	1m	15/10	-	11	0.019	0.33	2	34
24	5m comp	15/10	-	11	0.014	0.32	2	34
24	10m	15/10	-	12	0.060	0.80	1	34
31	5m comp	15/10	-	11	0.018	0.38	1	32
31	11m	15/10	-	11	0.070	0.80	2	34
44	1m	15/10	-	12	0.040	0.55	2	36

*comp - composite sample over the depth specified

Table 2: Chlorophyll a and Secchi disc values for Kahshe Lake, stations 13, 24 26 and 31, during 1971.

	Station 13		Station 24		Station 26		Station 31	
	Chloro a	S.D.	Chloro a	S.D.	Chloro a	S.D.	Chloro a	S.D.
May 27	1.8 µg/l	- m	2.1 µg/l	- m	2.6 µg/l	- m	2.5 µg/l	- m
May 28	2.3	-	2.1	-	2.3	-	2.6	-
May 29	2.4	-	2.6	-	2.3	-	2.3	-
May 30	2.9	2.0	2.5	2.5	2.5	2.5	2.0	2.5
May 31	2.8	-	2.5	-	3.1	-	2.1	-
August 20	3.6	3.0	3.7	3.0	2.9	3.0	4.0	3.0
August 21	6.4	3.0	3.9	3.0	4.4	3.0	3.7	3.0
August 22	4.6	3.0	5.0	2.7	3.8	3.0	5.1	3.0
August 23	5.9	3.0	3.9	3.0	4.4	3.0	4.2	3.0
August 24	5.4	3.0	3.7	3.0	4.1	3.0	4.6	2.7
October 11	2.4	2.3	2.0	2.1	-	-	2.7	2.1
October 12	1.7	2.5	1.8	2.0	-	-	2.4	2.5
October 13	-	-	-	-	-	-	2.3	2.0
October 14	1.3	2.0	3.2	2.5	-	-	2.7	2.5
October 15	1.7	2.0	2.3	2.5	-	-	3.0	2.5

Chloro a = Chlorophyll a

S.D. = Secchi Disc

µg/l = Micrograms/litre

m = meters

EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

F	-	the calculated analysis of variance statistic on F ratio.
df	-	degrees of freedom of the F ratio for "between group" and "within group" variation.
F(5%)	-	the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.
log GM	-	the logarithm (base 10) of the geometric mean.
S.E.	-	the standard error of the log GM where

$$S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$$

N	-	the number of values in the mean.
GM	-	the geometric mean of the bacterial level.
t	-	the calculated test of significance or student t-test used to compare stations, groups and a survey.

If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

SD refers to a significant difference at the .05 level but no significant difference at the .01 level.

SD* refers to a significant difference at the .01 level but no significant difference at the .001 level.

SD** refers to a significant difference at the .001 level.

TABLE 3

Summary of Analysis of Variance Grouping of Stations

Parameter - Total Coliform (TC)/100 ml

SURVEY	MAY 27 - 31	AUGUST 20 - 24	OCTOBER 11 - 15
Group	All Stations	All Stations	All Stations
F	4.992	1.333	3.140
df	48, 185	48, 192	48, 174
F(.05)	1.447	1.445	1.451
	SD	NSD	SD
Group	A All stations except 22, 24D, 26D, 31D, 38	A All stations except 8, 9	A Stations 1, 2, 4, 5, 6, 8, 10-14, 17-25, 26D, 45
F	1.134	.840	1.614
df	43, 167	46, 184	21, 78
F(.05)	1.470	1.454	1.697
	NSD	NSD	NSD
Log GM	1.579	1.037	2.513
SE	.018	.045	.308
N	211	231	100
GM	38	11	326
Group		B Stations 8, 9	B Stations 27-41
F		t = .4070	.9113
df		8	14,54
F(.05)		t(.05) = 2.306	1.84
		NSD	NSD
Log GM		2.172	2.738
SE		.2450	.027
N		10	69
GM		148	547
Group			C Stations 42-44
F			.224
df			2, 9
F(.05)			5.12
			NSD
Log GM			2.105
SE			.045
N			12
GM			127

TABLE 3 - continued

SURVEY	MAY 27 - 31	AUGUST 20 - 24	OCTOBER 11 - 15
Group			D Stations 15, 16
F			t = .4477
df			8
F(.05)			t(.05) = 2.306 NSD
Log GM			1.639
SE			.0745
N			10
GM			44
Group			E Stations 7, 9
F			t = .3685
df			6
F(.05)			t(.05) = 2.447 NSD
Log GM			1.998
SE			.0867
N			8
GM			100
Group			F Stations 26, 46
t			.1582
df			8
t(.05)			2.306 NSD
Log GM			2.3545
SE			.2716
N			10
GM			226

TABLE 4

Summary of Analysis of Variance Grouping of Stations

Parameter - Fecal Coliform (FC)/100 ml

SURVEY	MAY 27 - 31	AUGUST 20 - 24	OCTOBER 11 - 15
Group	All Stations	All Stations	All Stations
F	1.967	6.526	1.609
df	48, 185	48, 195	48, 176
F(.05)	1.447	1.444	1.450
	SD	SD	SD
Group	A All stations except 8, 9, 43, 44	A All stations except 5-10, 17, 18, 30, 33, 34, 40-44	A All station except 2, 34
F	1.134	1.315	1.458
df	44, 171	32, 131	46, 169
F(.05)	1.465	1.541	1.48
	NSD	NSD	NSD
Log GM	.1309	.2181	.2950
SE	.0156	.0227	.0235
N	216	164	216
GM	1	2	2
Group	B Stations 8, 9	C Stations 5-10	
F	t = .679	2.428	
df	8	5, 24	
F(.05)	t(.05) = 2.306	2.620	
	NSD	NSD	
Log GM	.6624	1.2660	
SE	.1923	.0999	
N	10	30	
GM	5	18	
Group	C Stations 43, 44	D Stations 41-44	
F	t = .3102	.3142	
df	6	3, 16	
F(.05)	t(.05) = 2.447	3.24	
	NSD	NSD	
Log GM	.5841	.6848	
SE	.1725	.0977	
N	8	20	
GM	4	5	

TABLE 4 - continued

SURVEY	MAY 27 - 31	AUGUST 20 - 24	OCTOBER 11 - 15
Group		E Stations 33, 34	
t		1.416	
df		8	
t(.05)		2.306 NSD	
Log GM		.863	
SE		.1417	
N		10	
GM		7	
Group		F Stations 17, 18	
t		.414	
df		8	
t(.05)		2.306 NSD	
Log GM		.7164	
SE		.1011	
N		10	
GM		5	

TABLE 5

Summary of Analysis of Variance Grouping of Stations

Parameter - Fecal Streptococcus (FS)/100 ml

SURVEY	MAY 27 - 31	AUGUST 20 - 24	OCTOBER 11 - 15
Group	All Stations	All Stations	All Stations
F	.677	1.504	1.624
df	48, 185	48, 194	48, 176
F(.05)	1.447	1.444	1.450
	NSD	SD	SD

Group	A All stations	A All stations except 2, 7, 8, 9, 10	A All station except 1, 2, 34, 43
F		1.070	1.099
df		43, 174	44, 163
F(.05)		1.468	1.468
		NSD	NSD
Log GM	.0859	.2906	.1655
SE	.0129	.0238	.0177
N	234	218	208
GM	1	2	1

Group		G Stations 7 - 10	G Stations 1, 2
F		.019	t = .0127
df		3, 16	6
F(.05)		3.244	t(.05) = 2.447
		NSD	NSD
Log GM		.7513	.5765
SE		.1464	.1488
N		20	8
GM		6	4

GLOSSARY OF TERMS

ALKALINITY	:The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydrozide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.
ANOXIC	:Refers to conditions when no oxygen is present.
BACKGROUND COLONIES	:Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.
CHLORIDE	:Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.
CHLOROPHYLL *a*	:A green pigment in plants.
CONDUCTIVITY	:Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.
DIATOMS	:Unicellulr plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.
EPILIMNION	:Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.
EUPHOTIC ZONE	:The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.
EUTROPHIC	:Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

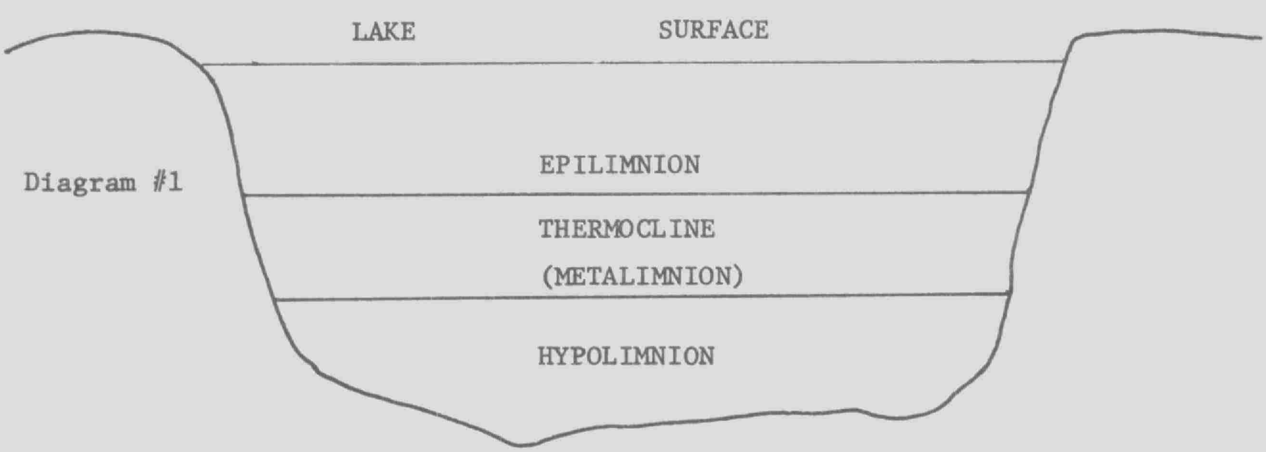
EUTROPHICATION	:The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
FECAL COLIFORMS (FC)	:Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.
FECAL STREPTOCOCCUS (FS)	:Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.
HARDNESS	:Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.
HYPOLIMNION	:The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1
KJELDAHL NITROGEN	:Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).
MESTROPHIC	:Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
METALIMNION	:See thermocline.
OLIGOTROPHIC	:Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.
pH	:Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.
PHOSPHORUS (TOTAL)	:Sum of all forms of phosphorus present in the sample.

SECCHI DISC :A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

THERMAL STRATIFICATION :During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.

THERMOCLINE (metalimnion) :The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding 1°C increase per meter.

Diagram #1



TOTAL COLIFORMS (TC) :Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

TROPHIC STATUS :Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS (continued)

:oligotrophic, mesotrophic and eutrophic. If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

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Microbiological Criteria
Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least 10 samples per month, including samples collected during weekend periods.

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